ESA POSITION STATEMENT: ECOSYSTEM MANAGEMENT IN A CHANGING CLIMATE

Ecosystems are already responding to climate change. Continued warming—some of which is now unavoidable—may impair the ability of many such systems to provide critical resources and services like food, clean water, and carbon sequestration. Buffering against the impacts of climate change will require new strategies to both *mitigate* the extent of change and *adapt* to changes that are inevitable. The sooner such strategies are deployed, the more effective they will be in reducing irreversible damage.

Ecosystems can be managed to limit and adapt to both the near- and long-term impacts of climate change. Strategies that focus on restoring and maintaining natural ecosystem function (reducing deforestation, for example) are the most prudent; *strategies that drastically alter ecosystems may have significant and unpredictable impacts.*

THE REALITY OF CLIMATE CHANGE: The Earth is warming—average global temperatures have increased by 0.74° C (1.3° F) in the past 100 years. The scientific community agrees that catastrophic and possibly irreversible environmental change will occur if average global temperatures rise an additional 2°C (3.6° F). Warming to date has already had significant impacts on the Earth and its ecosystems, including increased droughts, rising sea levels, disappearing glaciers, and changes in the distribution and seasonal activities of many species.

THE SOURCE OF CLIMATE CHANGE: Most warming seen since the mid 1900s is very likely due to greenhouse gas emissions from human activities. Global emissions have risen rapidly since pre-industrial times, increasing 70% between 1970 and 2004 alone.

THE FUTURE OF CLIMATE CHANGE: Even if greenhouse gas emissions stop immediately, global temperatures will continue to rise at least for the next 100 years. Depending on the extent and effectiveness of climate change mitigation strategies, global temperatures could rise 1-6° C (2-10° F) by the end of the 21^{st} century, according to the Intergovernmental Panel on Climate Change. Swift and significant emissions reductions will be vital in minimizing the impacts of warming.

MITIGATION: MANAGING ECOSYSTEMS TO LIMIT CLIMATE CHANGE

Decision makers now have a number of options for reducing atmospheric carbon dioxide (CO_2), ranging from improving energy efficiency and regulating emissions to sequestering carbon in geological reservoirs. While such strategies should be considered as part of a long-term solution, they may take some time to deploy. Ecosystems, meanwhile, can substantially offset human-generated emissions by naturally sequestering carbon, incorporating it through photosynthesis and storing it as organic matter. Ecosystem management therefore represents an effective and immediately available means of partially mitigating climate change.

Management strategies can help limit climate change by 1) accelerating the uptake of carbon into ecosystems and 2) preventing the release of carbon already stored. Current options range from protecting forests to reducing agricultural emissions to boosting carbon uptake above natural capacity. However, since ecosystems are sensitive to environmental change and their function is regulated through complex relationships and feedback loops, the less management strategies propose to alter natural environments, the better we can gauge their potential impacts.

The following actions will help ensure that limitation strategies are both functional and sustainable:

Prioritize low-alteration strategies: The most straightforward approaches focus on preserving natural ecosystem function, thereby providing many additional benefits associated with habitat conservation. For example, reducing forest degradation—long promoted as a way to protect forest species and conserve water—allows trees to store much more carbon over time and keeps stored carbon undisturbed. This means that ecosystem destruction has the double impact of removing sources of sequestration and releasing carbon already stored. Deforestation, in fact, is now second only to industrial emissions as a contributor to atmospheric CO_2. In agricultural systems, applying fertilizers in ways that increase the efficiency of incorporation into crops offers significant benefits to the environment, both in reducing greenhouse gas emissions and improving surrounding water quality.

Critically evaluate management-intensive strategies: Many approaches seek to enhance the sequestration potential of ecosystems beyond natural levels, offering the benefits of reduced greenhouse gas concentrations without requiring significant changes in land-use. Such management strategies may be accompanied by undesirable side effects, however, and should therefore undergo thorough evaluation prior to implementation. Increasing carbon uptake on agricultural lands, for example, may require a great deal more fertilizer than standard processes—a problematic tradeoff given the high emissions and pollution associated with producing and using chemical fertilizers.

Acknowledge the ecological implications of geoengineering: Some approaches seek to limit warming by engineering the environment, or "geoengineering." Such strategies could have unintended negative, possibly catastrophic impacts, some of which may only emerge after long-term or widespread use. For example, injecting sulfur particles into the upper atmosphere to reflect solar rays could have an immediate cooling effect but could also increase acid rain and ozone layer degradation, destabilize weather patterns, and could negatively affect ecosystems and human health. Efforts to limit climate change may eventually benefit from certain geoengineering strategies, *but until additional research confirms the safety and efficacy of these strategies, they should be avoided.*

Address long-term risks: Ecosystem alterations can have far-reaching consequences, some of which may not emerge for several decades. To help prevent negative impacts, assessments should both monitor existing carbon stores and use multi-decadal models to predict how ecosystems will respond to new management practices.

ADAPTATION: MANAGING ECOSYSTEMS TO WITHSTAND CLIMATE CHANGE IMPACTS

Management strategies have traditionally operated under the assumption that natural systems fluctuate within a certain range—the past has served as an indicator of future conditions. But this assumption does not hold in the face of rapid climate change. Even conservative warming projections show that natural systems will experience unprecedented stresses, including shifting habitats and ecological processes (e.g. wildlife migration and reproduction) and more frequent and severe natural disturbances, such as fires, floods, and droughts. These unavoidable changes will require management that addresses ecological thresholds, tipping points, and other sources of uncertainty. Ecosystems are naturally dynamic and diverse—they are the products of change and adaptation. But human activity has impaired the ability of many systems to respond. Preserving natural function is central to maintaining resilience and safeguarding ecosystem services in the face of climate change.

Adaptation strategies should:

Take additional steps to protect water quality and quantity: Water is critical to life, and its availability is directly connected to many important ecosystem services, including food production, regional cooling, and electricity from hydropower. Climate change puts freshwater resources at particular risk, however; rising temperatures have already led to lower river flows, warmer waters, and the drying out of wetlands. These impacts are compounded by human activities; in the western US, for example, nearly all water is already appropriated for human use. In many cases, the sustainability of freshwater resources will depend as much on the tradeoffs society makes to protect them as it will on direct impacts from warming.

Enable natural species migration across human dominated landscapes: Studies indicate that climate change has already affected over half of the world's wild species. Plants and animals are often adapted to narrow climatic ranges. As temperatures rise, many habitats are shifting closer to the poles or higher altitudes, forcing species to follow. But extensive changes in land use over the last 100 years have fragmented habitats, limiting species' ability to migrate. Effectively squeezed from their habitats, many species are increasingly at risk of extinction. Creating and maintaining wildlife corridors across jurisdictions and private lands will help species adapt.

Improve capacity to predict extreme events: Natural disturbances like wildfires and major storms are often important to ecosystem self-regulation, and many species are well-adapted to these events. But as event frequency and intensity increase, monitoring and modeling efforts at all scales will be imperative in efforts to understand and respond to novel rates and intensities of environmental change.

Manage collaboratively at the ecosystem level: Climate change is already affecting the ability of ecosystems to provide vital resources. Addressing the resulting shortages is a complex task, compounded by diverse ecological and political priorities. Many natural resources and services—fresh water, clean air, crop pollination—are not contained within governmental boundaries and are often not uniformly accessed, used, and valued. The effective management of these resources demands strategies that operate at the ecosystem level, rather than within jurisdictional boundaries. Effective management will require extensive collaboration and cooperation, across borders and between public and private sectors.